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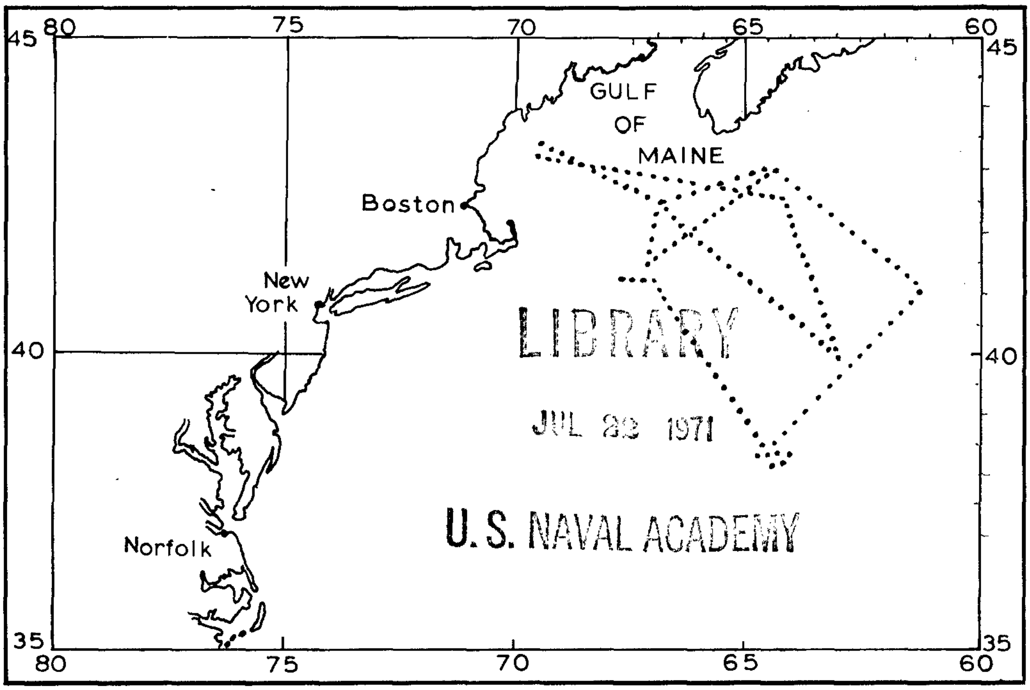
IR NO. 68-17

INFORMAL REPORT

OCEANOGRAPHIC CRUISE SUMMARY EASTERN GULF OF MAINE AND CONTINENTAL MARGIN



FEBRUARY 1968

NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

INFORMAL REPORT

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ABSTRACT

A survey by USNS SILAS BENT (T-AGS 26) was conducted during September-October 1966, in an area south of Cape Sable and extending from the Gulf of Maine to the Sohm Abyssal Plain. Six oceanographic stations were occupied providing additional insight into the water mass structure of the area, and together with sea surface temperature records, partially delineated the inshore edge of the Gulf Stream. Continuous seismic profiling data reveal a flank of Kelvin Seamount overlain by sediments as much as 1 km thick. Sand waves in the Northeast Channel of the Gulf of Maine were observed. Field training of personnel in oceanographic techniques was provided as well as further evaluation of the BENT's Shipboard Oceanographic Survey System (SOSS).

Vance G. Sprague, Jr.

ASW/USW Survey Project
Deep Ocean Surveys Division
Oceanographic Surveys Department

This report has been reviewed and is approved for release as an unclassified Informal Report.

C. H. Cline

C. H. CLINE
Director, Deep Ocean Surveys Division

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OCEANOGRAPHIC CRUISE SUMMARY

I. PREVIOUS KNOWLEDGE OF THE REGION

The survey area as shown in Figure 1 has been the subject of numerous investigations, especially during this century. Woods Hole Oceanographic Institution has provided much information on the area including Iselin and Fuglister's studies of the western North Atlantic, Stommel's description of the Gulf Stream in 1965, and Emery and Uchupi's investigations concerning the geology of the Gulf of Maine and Georges Bank. Heezen and others at the Lamont Geophysical Observatory have supplied considerable knowledge of the bottom characteristics of the survey area. Bigelow (Harvard) in 1924, reported on the physical oceanography of the Gulf of Maine and Sverdrup, Johnson and Fleming in 1942 presented definitions of the area's water masses.

Four general oceanographic provinces are present in the area: (a) coastal water in the Gulf of Maine outward across the continental shelf, (b) slope water seaward to, (c) the Gulf Stream system, and (d) the Sargasso Sea east of the Gulf Stream (Iselin 1936, Sverdrup et al 1942). The Gulf of Maine water is relatively fresh (usually less than 34‰ and subject to temperature variations due to seasonal changes and mixing (Bigelow 1924). Slope water, while exhibiting mixing zone characteristics in the upper 200 meters due to infusions of coastal and Gulf Stream waters, is similar to, but slightly less saline at given temperatures than, North Atlantic Central Water at intermediate depths (Iselin 1936). Church (1937) has found that frequently an abrupt break in temperature is evident defining the coastal/slope water boundary south of Georges Bank. Isotherms generally slope downward in an off shore direction (Iselin 1936). Seaward is the Gulf Stream which may be considered a pressure gradient zone between the warm, saline water of the Sargasso Sea and the colder, fresher slope water (Stommel 1965). Accurate delineation of the Gulf Stream proper requires detailed sections across the area since semipermanent eddies frequently form, particularly on the inshore side of the main stream. Beyond the Gulf Stream is the Sargasso Sea composed of North Atlantic Central Water to a depth of about 1600 meters (Iselin 1936). Here the surface variations are less pronounced than with slope water but, due probably to seasonal phenomenon, the depth of the thermocline often varies considerably resulting in temperature/salinity disagreements between some individual stations (Iselin 1936). However, T-S curves for this water mass are nearly straight between the points T=8°C, S=35.10 ‰ and T=19°C, S=36.70 ‰ (Sverdrup et al 1942). Underlying the Gulf Stream, North Atlantic Central Water and, to some extent, the slope water (generally below 1600-2000 meters), is another water mass termed Deep Water which comprises the majority of all water in the North Atlantic Ocean. Characteristics of Deep Water are temperature ranges of 2.2°C to 3.5°C and salinities of 34.90 ‰ to 34.97 ‰ (Sverdrup et al 1942).

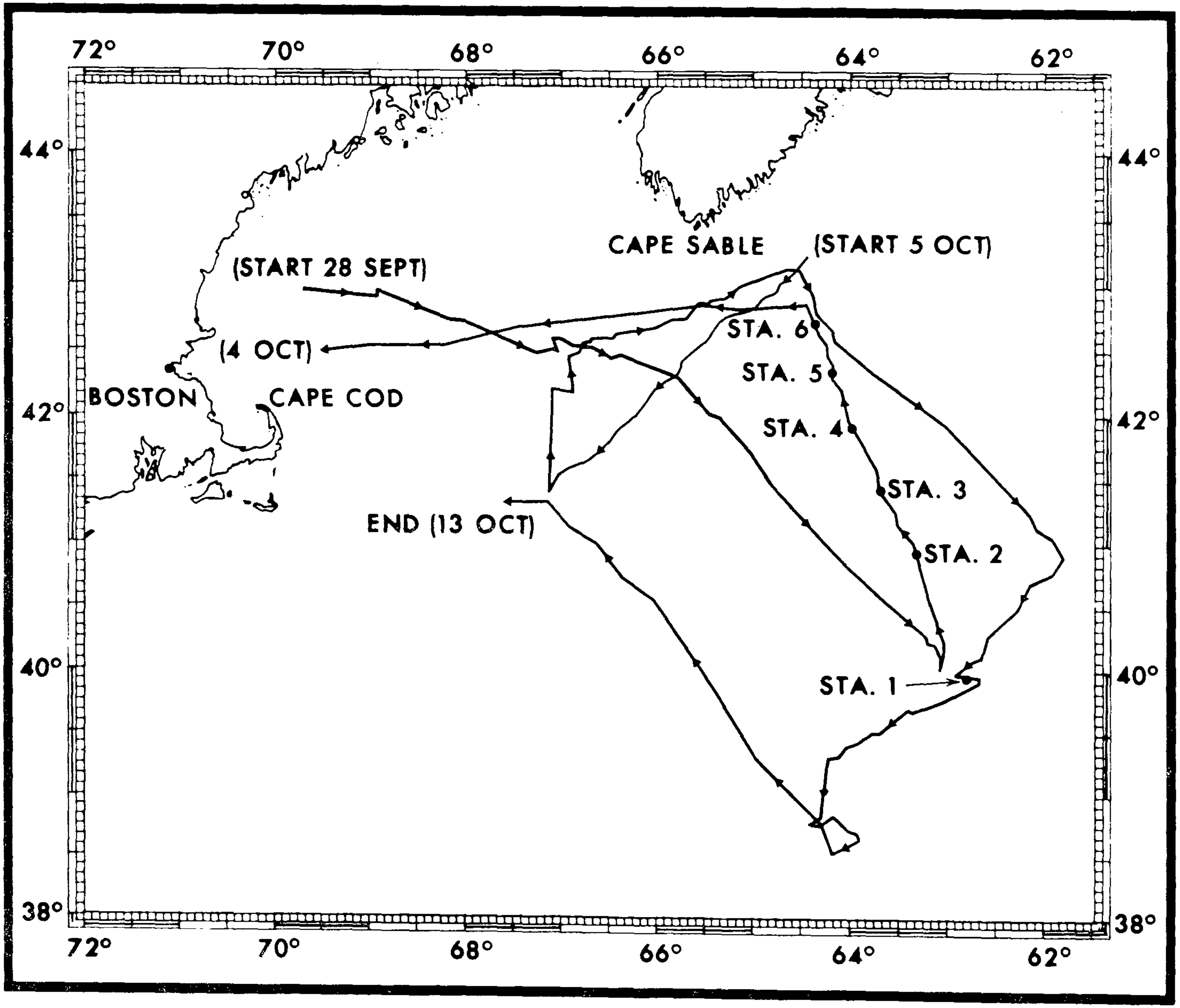

FIGURE 1 TRACK CHART AND STATION LOCATION

The survey area is geologically composed of four physiographic provinces: (a) the continental shelf (Gulf of Maine), (b) continental slope, (c) continental rise, and (d) abyssal plain. The Gulf of Maine is a rough shallow basin (mean depth, 150 meters) with a thin sediment cover over a crystalline basement. Georges and Browns Banks, which form the eastern boundary of the gulf, are characterized by depths of 50 to 90 meters and are composed of glacially eroded Cretaceous and Tertiary strata covered thinly by glacial outwash and more recent sediments (Emery and Uchupi 1965). The continental slope extends generally from the 50 to 100 fathom contour seaward about 30 miles to a depth of 750 to 1750 fathoms and is characterized by a gradient terminating at a low of 1:40. The continental rise continues downward with considerably less slope and forms the western boundary of the Sohm Abyssal Plain at a depth of about 2700 fathoms where the gradient is less than 1:1000 (Heezen et al 1959).

II. OBJECTIVES OF THE SURVEY

The purpose of the survey was to further investigate the geological structure of Georges Bank, the Continental Slope and Rise, and the Sohm Abyssal Plain. Oceanographic data was to be obtained to supplement existing knowledge of the physical characteristics of the water in the area and to provide personnel with experience in collection, reduction and evaluation of data. Continuation of the test and evaluation program of the installed Shipboard Oceanographic Survey System (SOSS) was to be performed.

III. NARRATIVE OF THE SURVEY

USNS SILAS BENT departed Portsmouth, New Hampshire, 28 September, 1966, and commenced underway data acquisition upon entering international waters. On 4 October, BENT was diverted to Boston to debark the chief scientist due to an emergency and the survey was resumed 6 October. Having completed operations, BENT arrived in New London, Connecticut, 14 October, 1966. Figure 1 shows the ship's track and the locations of oceanographic stations occupied during the survey.

IV. RESULTS OF THE SURVEY

During the survey, five SOSS stations and one Nansen station were occupied. Resulting data from the salinity sensor of the SOSS fish were subject to some doubt concerning their validity (see VI). One additional Nansen station was planned but had to be abandoned due to heavy seas. Underway sea surface temperature measurements were recorded over 1290 miles of track. Several bottom cores were attempted without success as the core

TABLE I

SUMMARY OF DATA

Continuous Seismic Profiling	1530 miles
Bathymetry	1530 miles
Sea Surface Temperature	1290 miles
Magnetics	1290 miles

Nansen Station	(#1)	39°54'N	62°42'W
SOSS Station	(#2)	40°56'N	63°26'W
SOSS Station	(#3)	41°25'N	63°40'W
SOSS Station	(#4)	41°54'N	63°50'W
SOSS Station	(#5)	42°20'N	64°04'W
SOSS Station	(#6)	42°46'N	64°19'W

barrels were bent upon impact with the bottom and no samples were obtained. Apparently, two primary factors combined to produce the poor coring results: i.e., the weight (2000 lbs), which was too great for the strength of the core barrel, and the relatively hard bottom cored, e.g. one core was attempted at the top of Kelvin Seamount. Underway bathymetry and seismic profiles were obtained over 1530 miles of track line. Sand waves were detected in the Northeast Channel of the Gulf of Maine by bathymetry and seismic profiles revealed the flanks of Kelvin Seamount overlain by nearly 1 km of sediments on the Sohm Abyssal Plain (see VI). A summary of data obtained is contained in Table 1.

V. METHODS OF COLLECTION AND ANALYSIS

A. Physical Oceanography

1. Temperature. Temperature measurements at station 1 (Fig. 2) were made at standard depths using paired protected deep sea reversing thermometers on Nansen bottles. Corrections to readings were applied in conformance with the methods described in H. O. Pub. 607. Thermometric depths were determined by the use of unprotected thermometers at all depths in excess of 100 meters. Continuous surface to bottom temperature profiles for stations 2 through 6 (Figs. 3-7) were obtained through the use of the temperature sensing component of the SOSS.

A general interpretation of sea surface contours from data obtained through the use of the ship's SOSS integrated, hull mounted temperature probe is presented in Figure 8. Data were initially recorded on magnetic tape and in chart form, scaled and plotted on the smooth track in the field. Ship tracks over which temperature data were recorded are indicated in Figure 8 by the dashed line.

Figures 9 and 10 present a cross section along the line of ocean stations from the Sohm Abyssal Plain to the Gulf of Maine. The vertical exaggeration in Figure 9 is considerably greater than that of Figure 10 in order to show the more detailed structure of the upper layers. Correlation of surface temperatures at the ocean stations with underway temperature measurements could not be fully accomplished since underway measurements were not recorded along the line of the section.

2. Sound Velocity. Continuous surface to bottom sound velocity profiles for stations 2 through 6 were obtained using the velocimeter component of the SOSS and sound velocities at station 1 were computed using Wilson's equation. (Figs. 2-7).

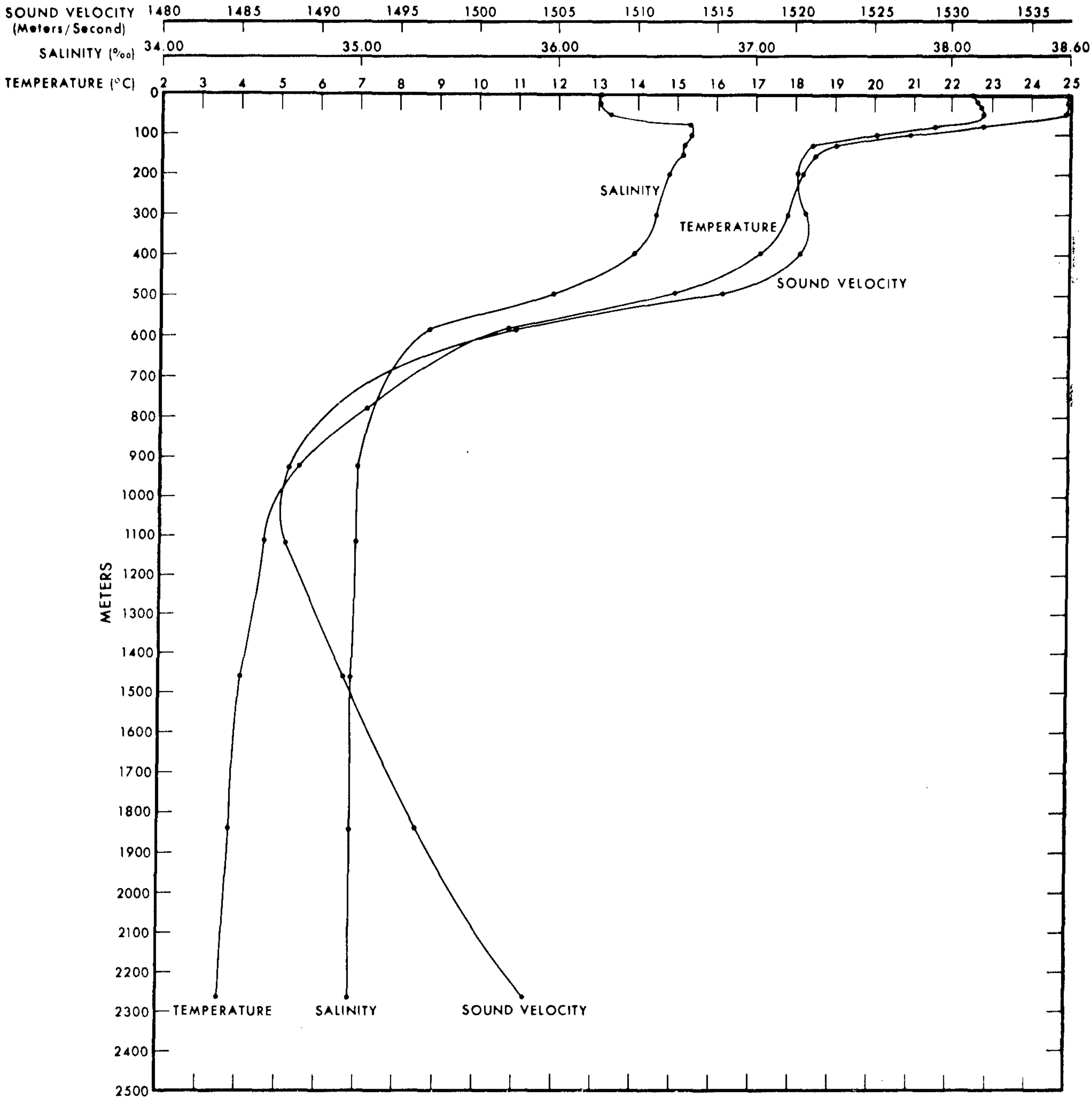

FIGURE 2 STATION 1
TEMPERATURE, SALINITY, SOUND VELOCITY PLOT
NANSEN CAST DATA

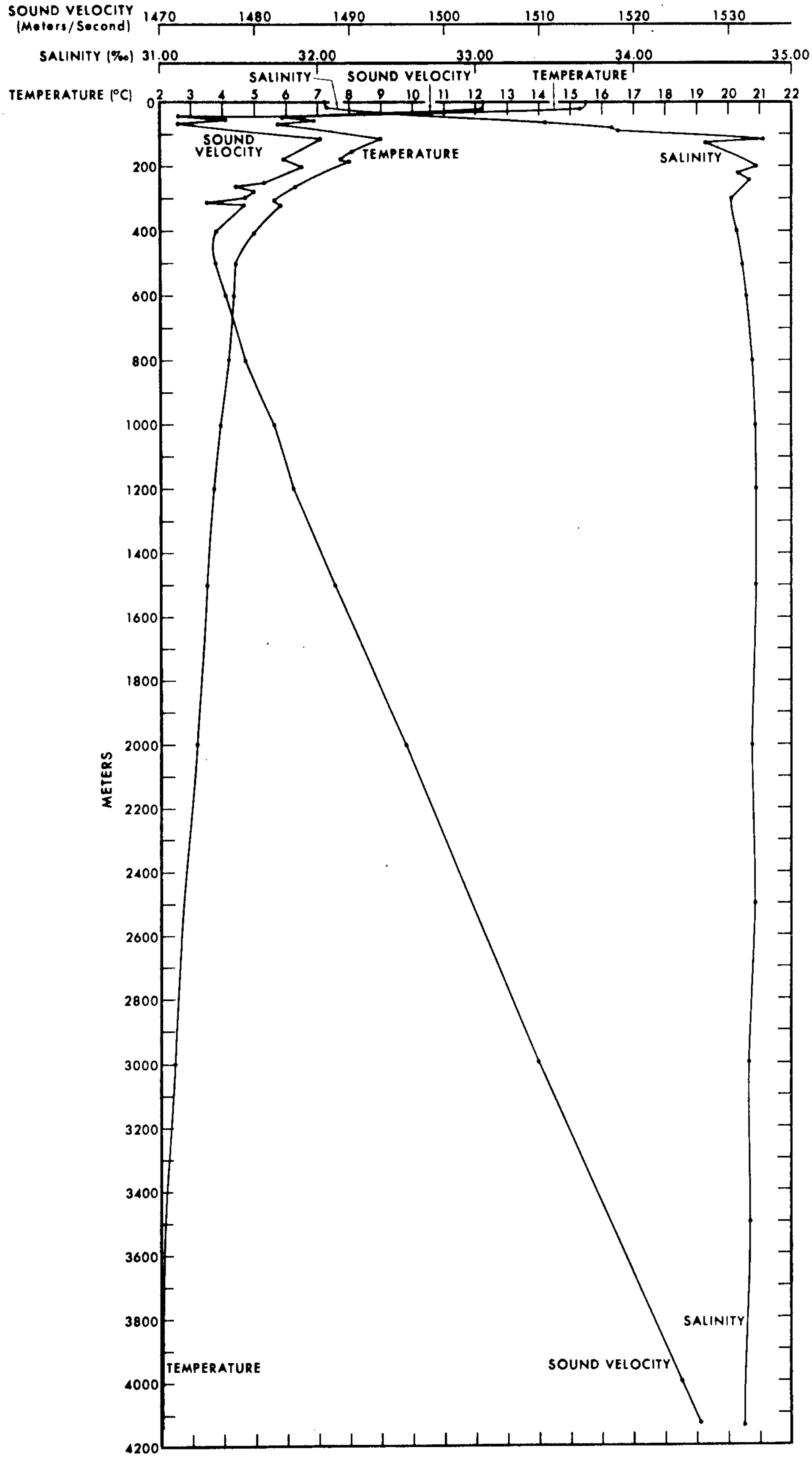

FIGURE 3 STATION 2
TEMPERATURE, SALINITY, SOUND VELOCITY PLOT
SOSS DATA

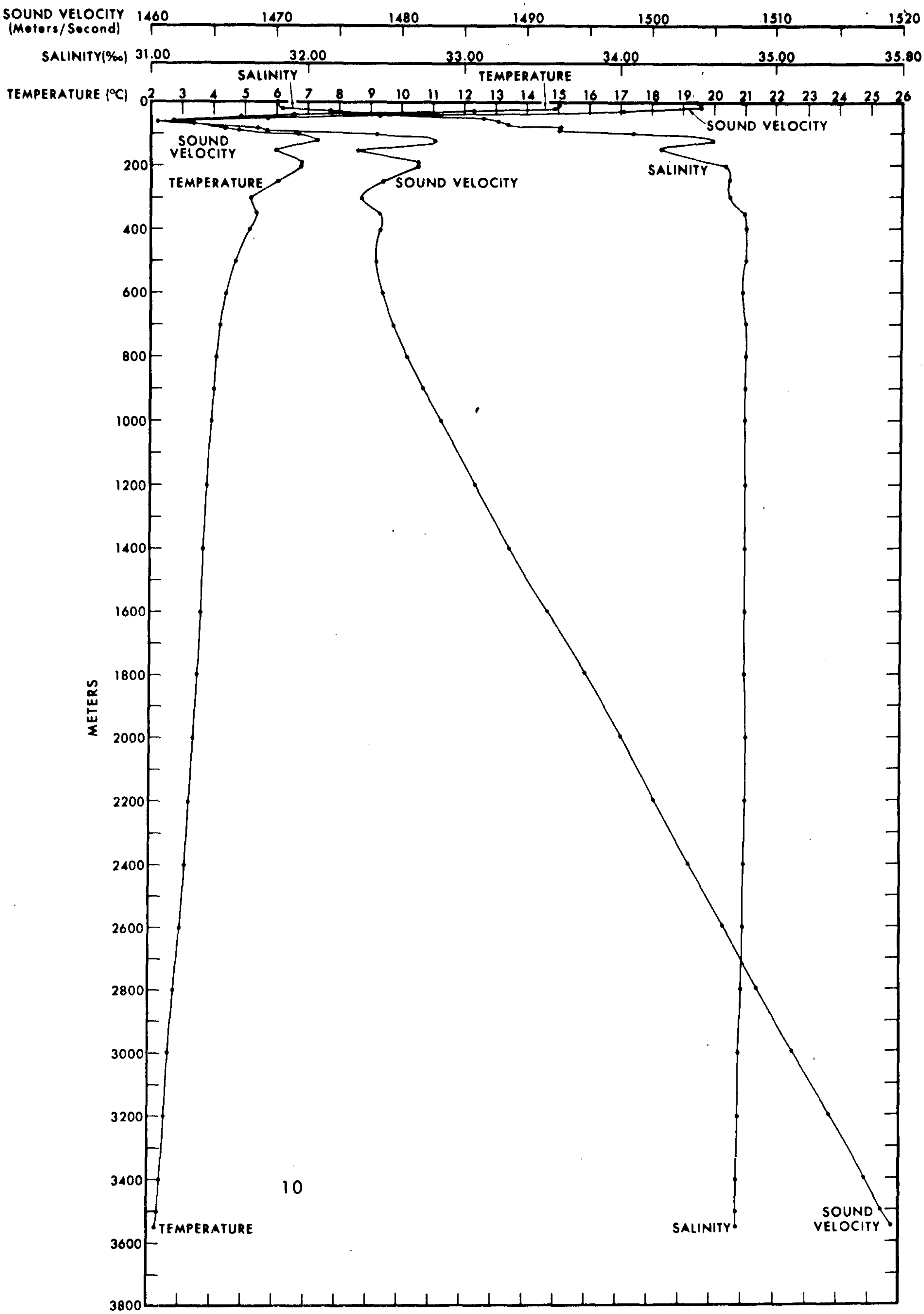

FIGURE 4 STATION 3
TEMPERATURE, SALINITY, SOUND VELOCITY PLOT
SOSS DATA

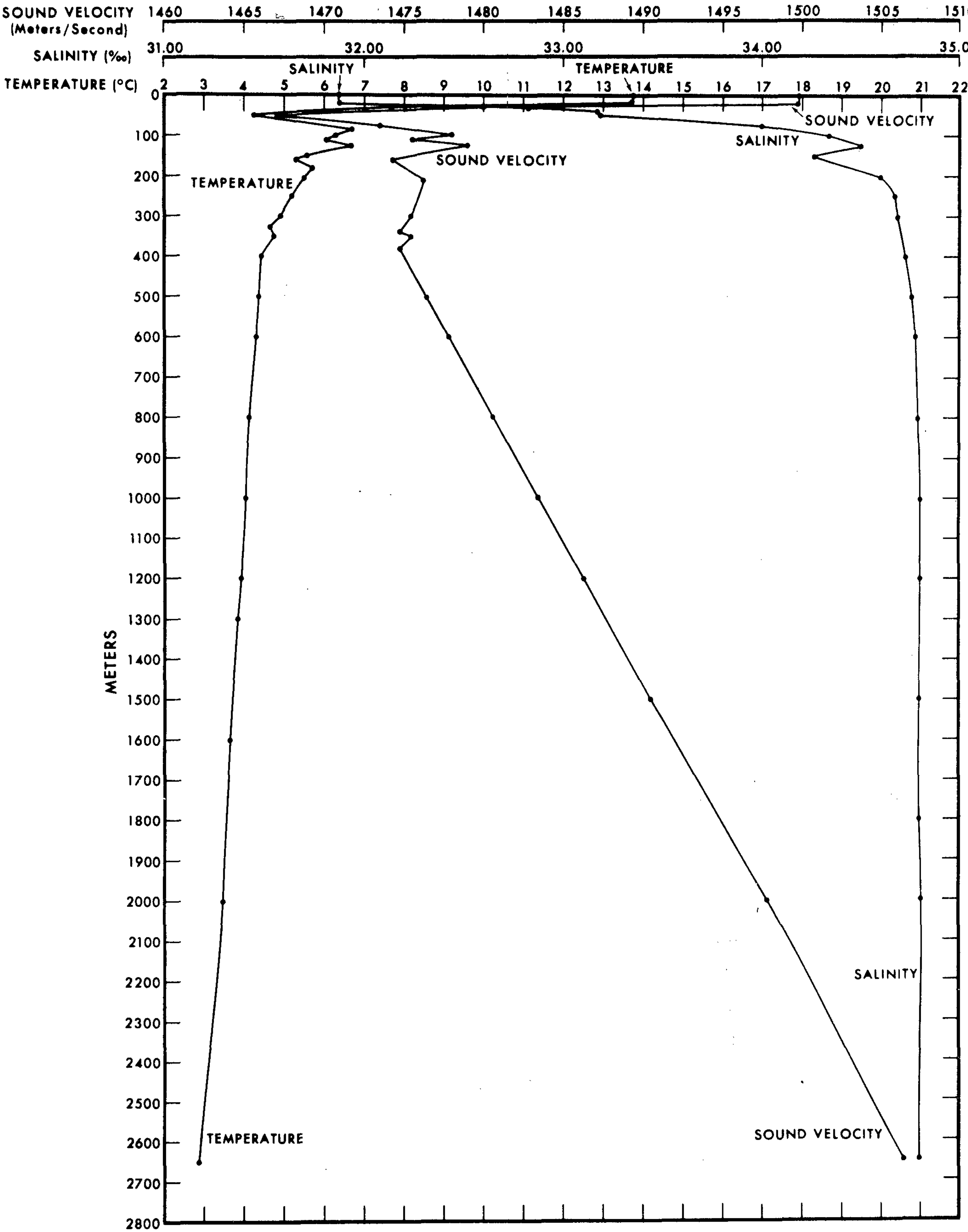

FIGURE 5 STATION 4
TEMPERATURE, SALINITY, SOUND VELOCITY PLOT
SOSS DATA

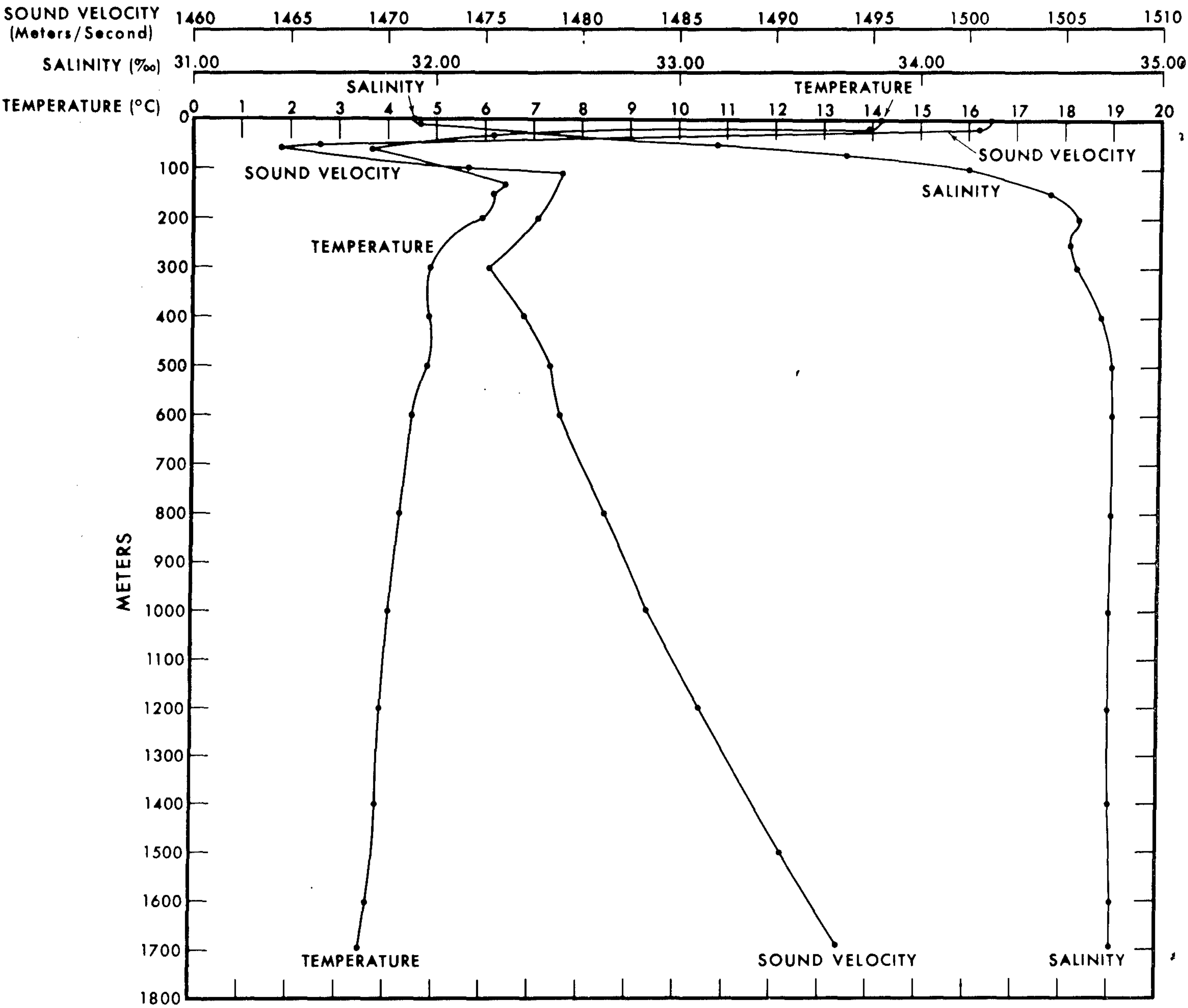

FIGURE 6 STATION 5

TEMPERATURE, SALINITY, SOUND VELOCITY PLOT

SOSS DATA

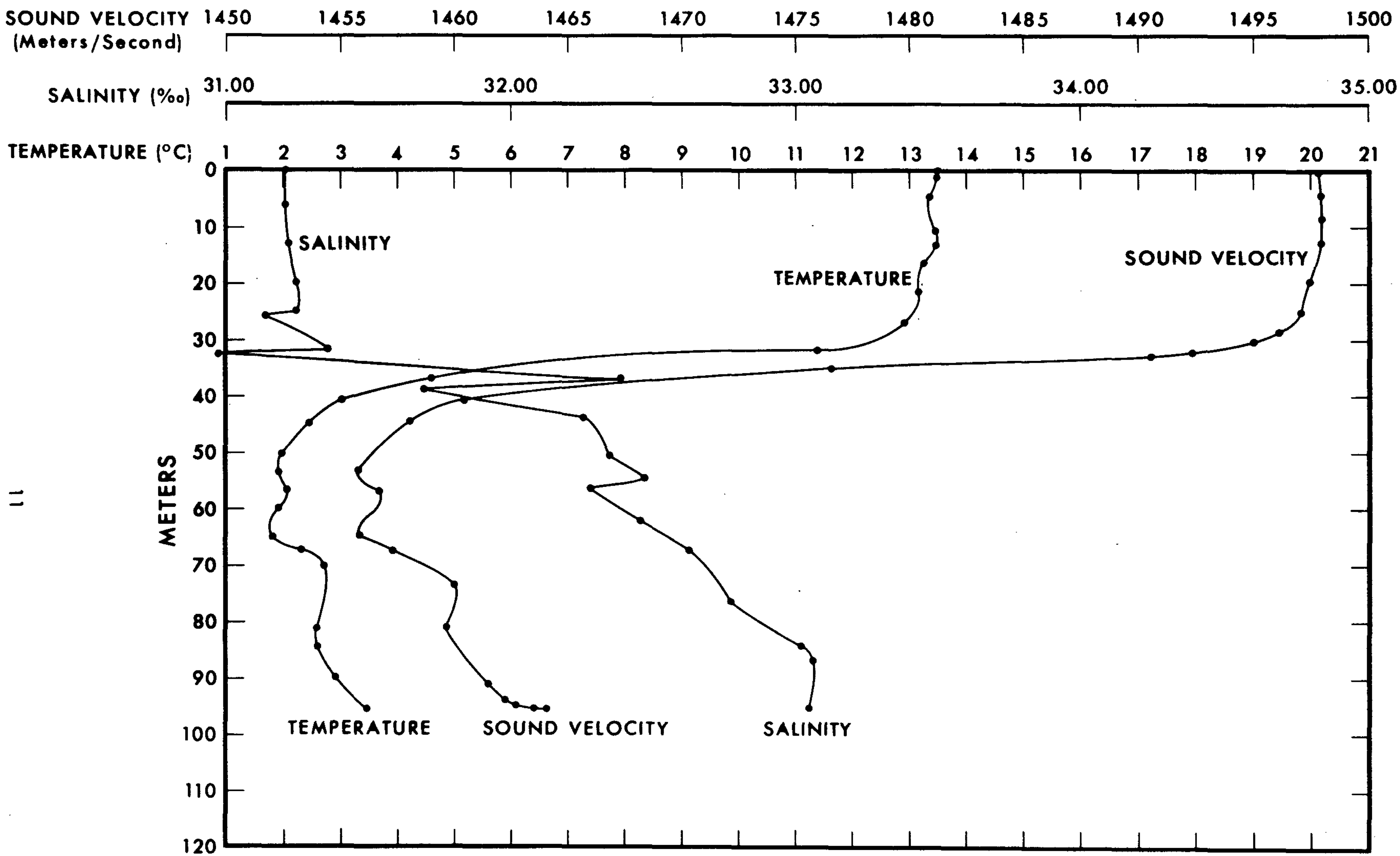

FIGURE 7 STATION 6

TEMPERATURE, SALINITY, SOUND VELOCITY PLOT
SOSS DATA

B. Chemical Oceanography

Salinity profiles for stations 2 through 6 were constructed from data obtained from the salinity sensing component of the SOSS. At station 1, water samples trapped by Nansen bottles at depth were analyzed on board ship using an Industrial Instruments inductively coupled salinometer standardized with Copenhagen Standard Sea Water. (Figs. 2-7).

C. Geological Oceanography

1. Bathymetry. Bathymetric data were continuously recorded on a model 419 Alden Precision Graphic Recorder (PGR) keyed from a Gifft transceiver. Pulse lengths of 2 ms or less were used when possible for optimum definition of bottom features and delineation of shallow sediment layering. The source was a wide beam, 12 KHz, EDO AT-200 transducer towed from the CEC winch on the stern of the BENT at a depth of 30 feet in a steel and fiberglass ORE housing. Data were removed from the recorder every 24 hours, scaled, and plotted on the smooth track. As the bathymetric subsystem of the SOSS was not considered fully operational, narrow beam data were collected only as required for test and evaluation of the SOSS.

2. Magnetics. Magnetics data were recorded continuously while underway by the magnetics subsystem which consisted of a Varian model 4937 proton precession magnetometer with the sensor towed 700 feet astern. Data were displayed graphically and retained on magnetic tape. Chart records were scaled and plotted on the smooth track while in the field.

3. Geophysics. Continuous sub-bottom profile (CSP) data were taken using the SOSS seismic subsystem. The source was an 18,000 joule EG&G sparker sled with power provided by the Texas Instruments capacitor banks. Signals were received on a TI hydrophone streamer towed approximately 200 feet astern. Data were monitered on an oscilloscope, filtered and recorded on 11 and 19 inch modified PGR recording heads. Broad band signals were recorded on magnetic tape for future playback.

VI. PRELIMINARY ANALYSIS

Sea surface temperature records (Fig. 8) show a gradual increase of about 6°C from the 100 fathom curve to the inshore side of the Gulf Stream as the continental slope was crossed normal to the bottom contours. The approximate inshore edge of the Gulf Stream is readily discernible on each of the three NW-SE tracklines by abrupt temperature increases of as much as 5°C over a horizontal distance of three miles. In the eastern corner of the area, surface temperature contours were constricted along the edge of

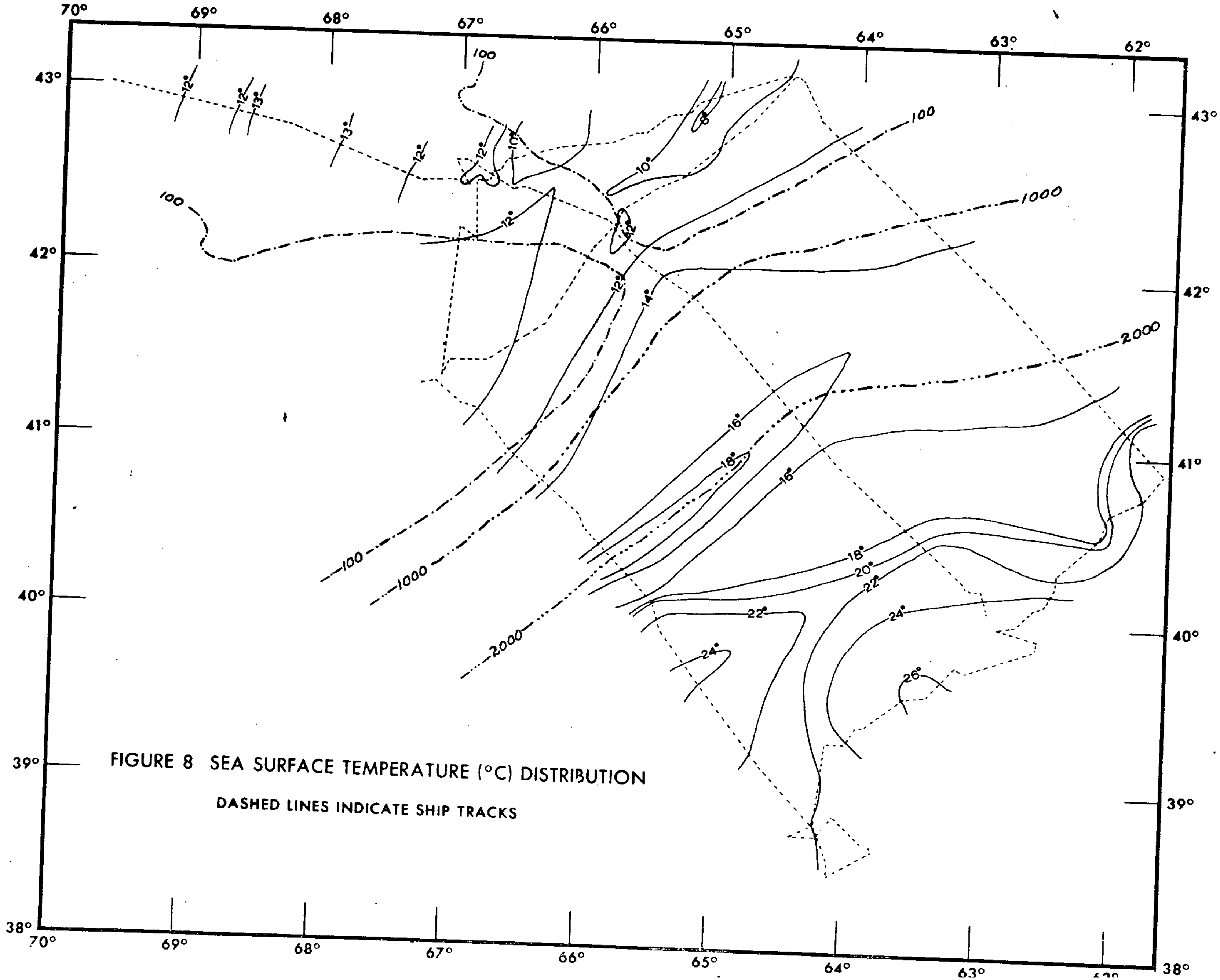

FIGURE 8 SEA SURFACE TEMPERATURE (°C) DISTRIBUTION

DASHED LINES INDICATE SHIP TRACKS

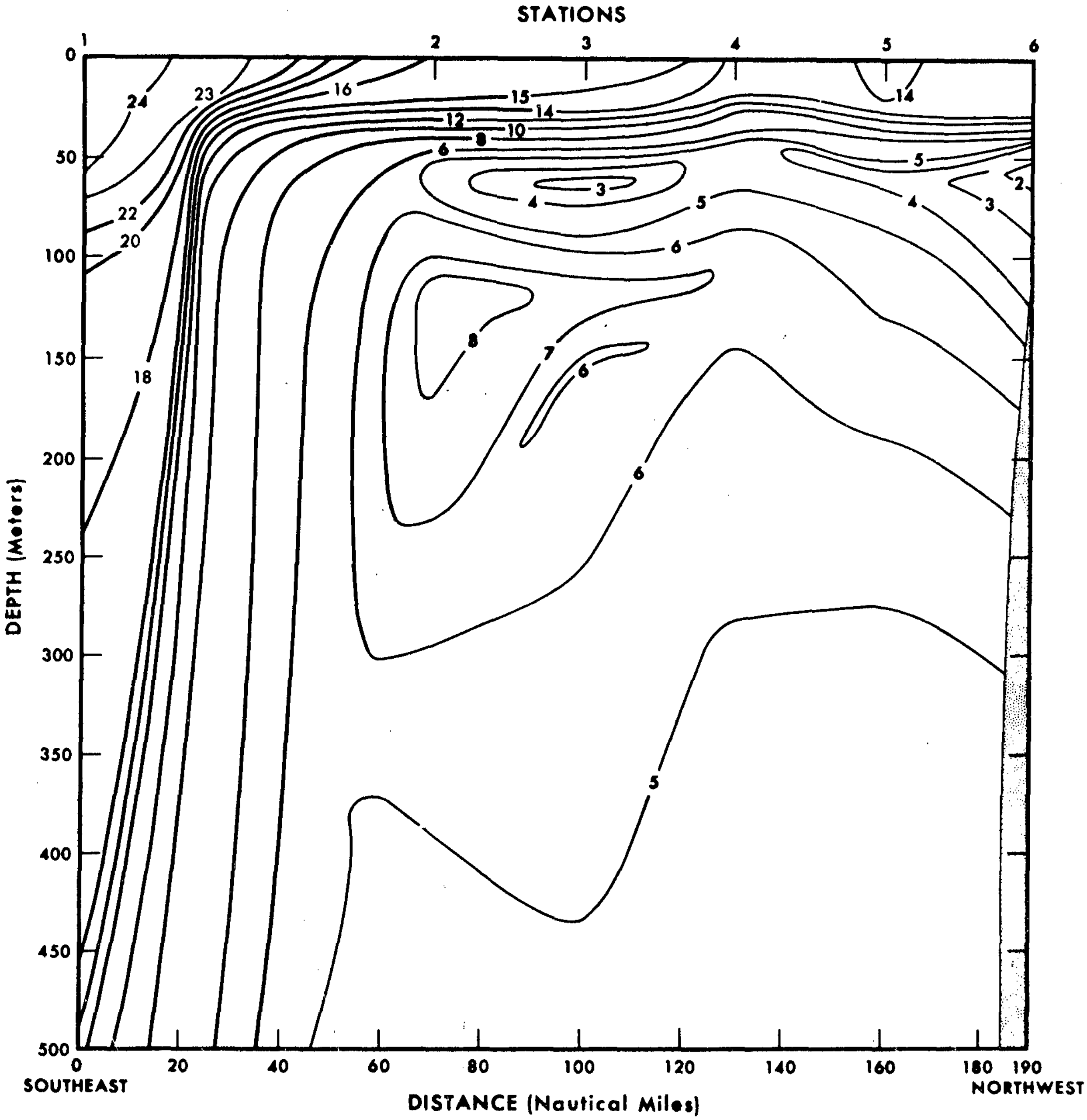

FIGURE 9 TEMPERATURE CROSS-SECTION, UPPER 500 METERS — SOHM ABYSSAL PLAIN TO BROWN'S BANK

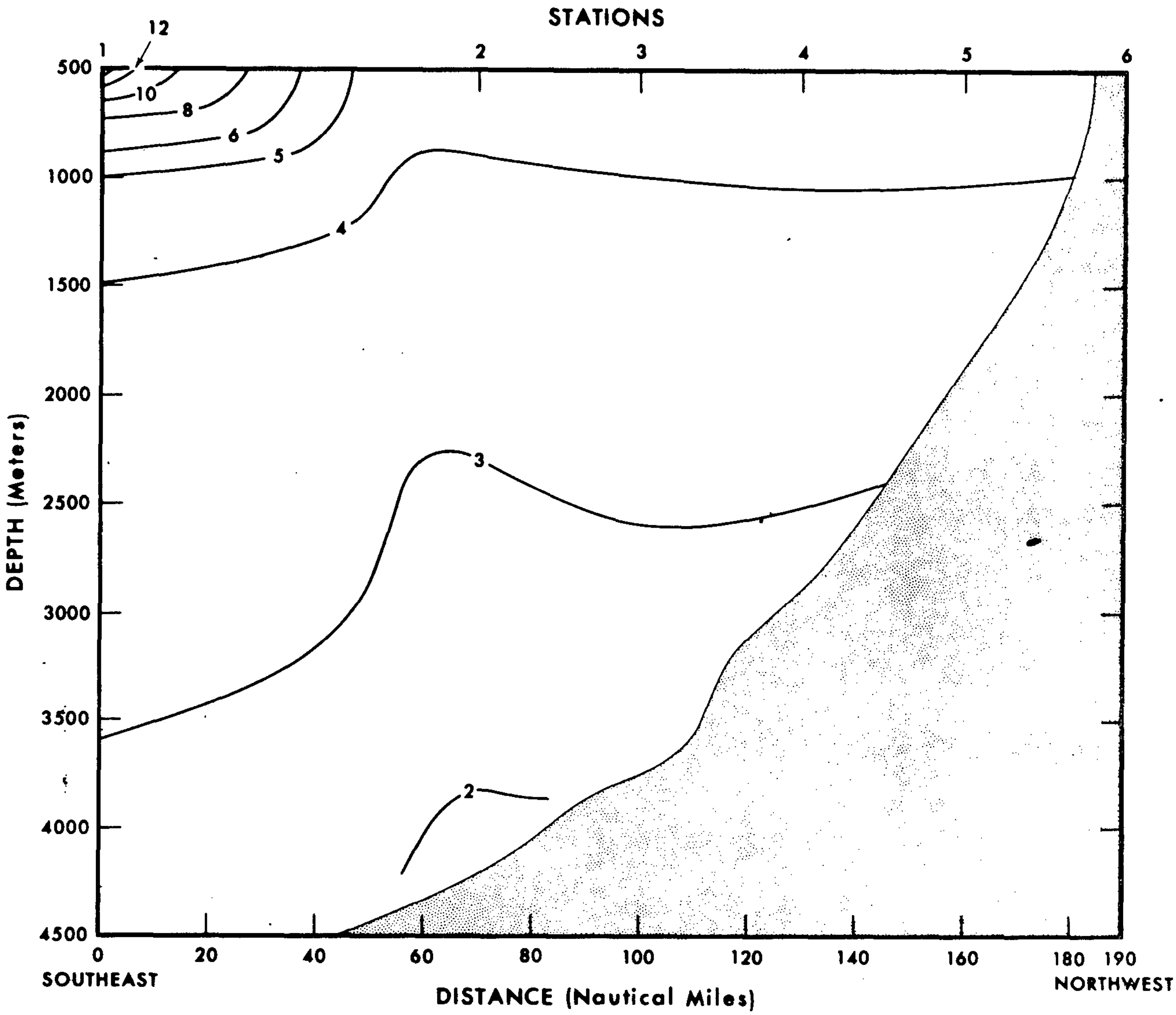

FIGURE 10 TEMPERATURE CROSS-SECTION, BELOW 500 METERS — SOHM ABYSSAL PLAIN TO BROWN'S BANK

a curved area of very warm water. No vertical temperature measurements were made in this area and, as the track line was not continued across the gradient, it was not possible to determine whether an eddy of the Gulf Stream or simply a meander of the main stream was encountered.

Preliminary analysis of the data from the line of ocean stations shows temperatures following the pattern described by the bulk of historical data. However, in determining water mass characteristics, salinity data from SOSS stations 2 through 5 (Figs. 3-6) do not relate to the water masses expected in the lower layers. The problem appears to center on the salinity sensor of the SOSS which recorded maximums of 34.82 °/₀₀ in contrast to Sverdrup's Deep Water values of 34.90 °/₀₀ to 34.97 °/₀₀. The maximum spread of salinity values from the four stations at depths below 1000 meters was .05 °/₀₀ which indicates close agreement considering the sensor's rated accuracy of ± .02 °/₀₀. Doubts concerning the data's validity are substantiated by salinity measurements at station 1 (Fig. 2) which were made by inductively coupled salinometer. The latter records are in agreement with published data on water mass characteristics and boundaries. The salinity sensor's previous history of unreliability gives more weight to the conclusion that either the equipment was not properly calibrated or the program for correcting the raw data was in error, rather than the detection of a previously undefined water mass.

The line of ocean stations extends from coastal water (station 6) to station 1, the only station taken within the limits of the Gulf Stream. The temperature cross sections (Figs. 9 & 10) show the existence of the characteristic steep thermal gradient.

Bathymetric data collected is in general agreement with published bathymetry along the survey tracks. However, along a four mile section of track on the north side of the Northeast Channel of the Gulf of Maine, sediment ridges were observed in approximately 135 fathoms of water (Fig. 11). The size and shape of these waves, some of which attain 20 ft. in amplitude and 1000 ft. in wavelength, compare favorably with the sand waves on Georges Shoal reported by Stewart and Jordan (1964). It appears from their configuration that current flow in that area is in a northwesterly direction: i.e., right to left as the figure is viewed.

Seismic profiles across the Gulf of Maine, Georges, and Browns Banks disclose a thin layer of sediment covering the basement structure. During three crossings over the continental slope, seismic records show up to 0.75 seconds of penetration (two way travel time) and define a fairly continuous layer approximately 400 meters below the bottom. This layer is rougher than the surface and outcrops two thirds of the way down the slope. The profiles also show evidence of slumping and strong reflectors near the surface which appear periodically down the slope and onto the continental rise. Seismic crossings of the continental rise show a relatively rough, gently sloping bottom with many discontinuous sub-bottom reflectors.

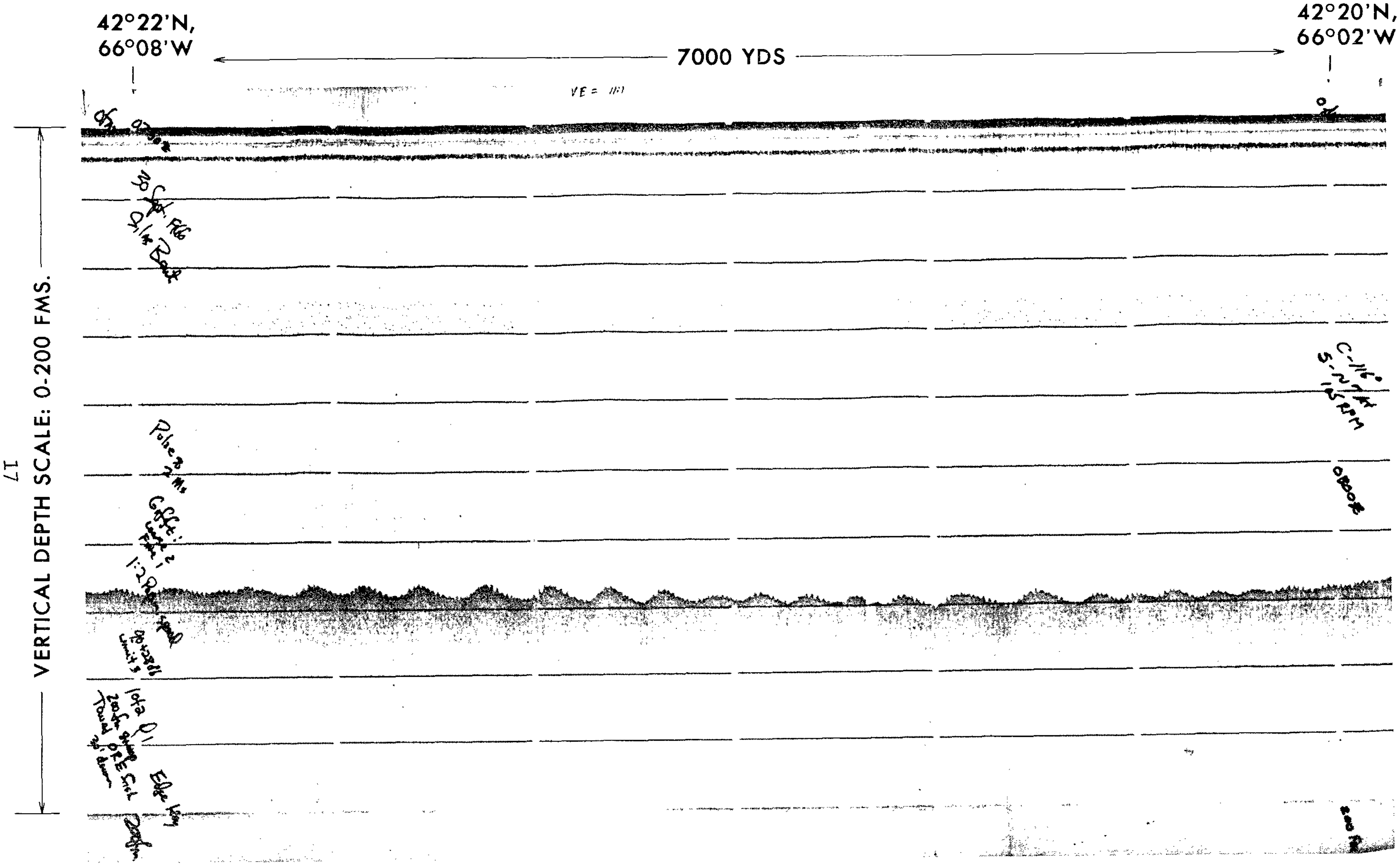

FIGURE 11 SAND WAVES — EASTERN CHANNEL, GULF OF MAINE

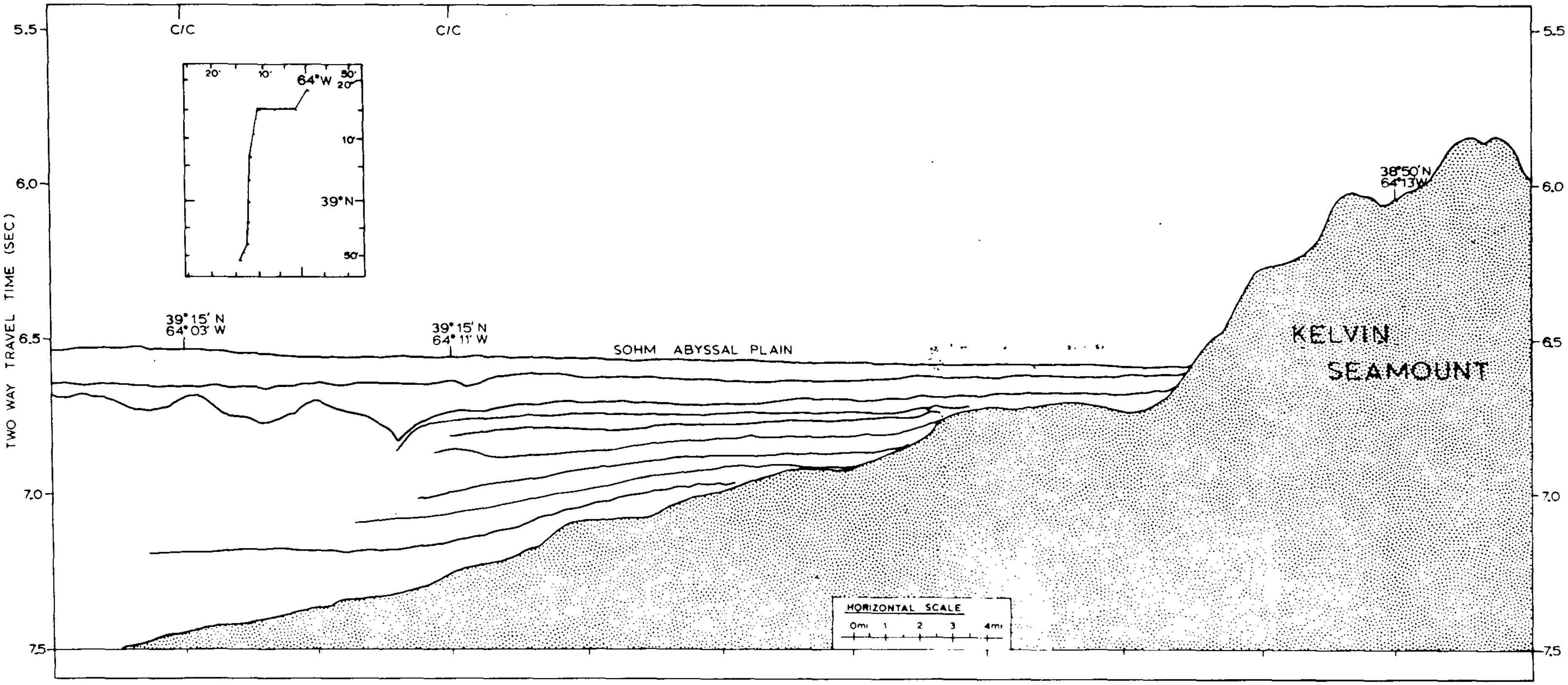

FIGURE 12 SEISMIC PROFILE — KELVIN SEAMOUNT

In the Sohm Abyssal Plain, seismic records reveal a flank of Kelvin Seamount overlain by approximately 1 km of sediment. Figure 12 shows the seamount profile which was traced nearly 18 miles until it emerged from the bottom. Sediment cover on the slope and top of the seamount is thin or non-existent. Elsewhere in the abyssal plain, five to six shallow reflectors are identifiable lying parallel to the bottom.

VII. DISPOSITION OF DATA

All data are located in Code 9310 with the exception of magnetic tapes from the Shipboard Survey System which are retained by Code 12.

VIII. ADDITIONAL WORK NEEDED IN THE AREA

The region of the survey has been investigated perhaps more than any other area in the North Atlantic. However, bottom samples at selected points, particularly in a line from the Gulf of Maine down slope to the abyssal plain should provide more conclusive evidence of possible glacial sediment transport seaward through the Northeast Channel and slumping down the Continental Slope. Further seismic studies in the Sohm Abyssal Plain could more completely define to what extent Kelvin Seamount and others are buried beneath the sediments. A more detailed bathymetric study of the sand waves in the Eastern Channel of the Gulf of Maine might prove helpful in understanding current and sediment flow in the channel.

Acknowledgements: I wish to thank Mr. Willis Hammond and Mr. Robert Feden, Chief Scientists on the cruise, for assistance with geophysical data.

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Gulf of Maine						
Sand Waves						
Kelvin Seamount						

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